

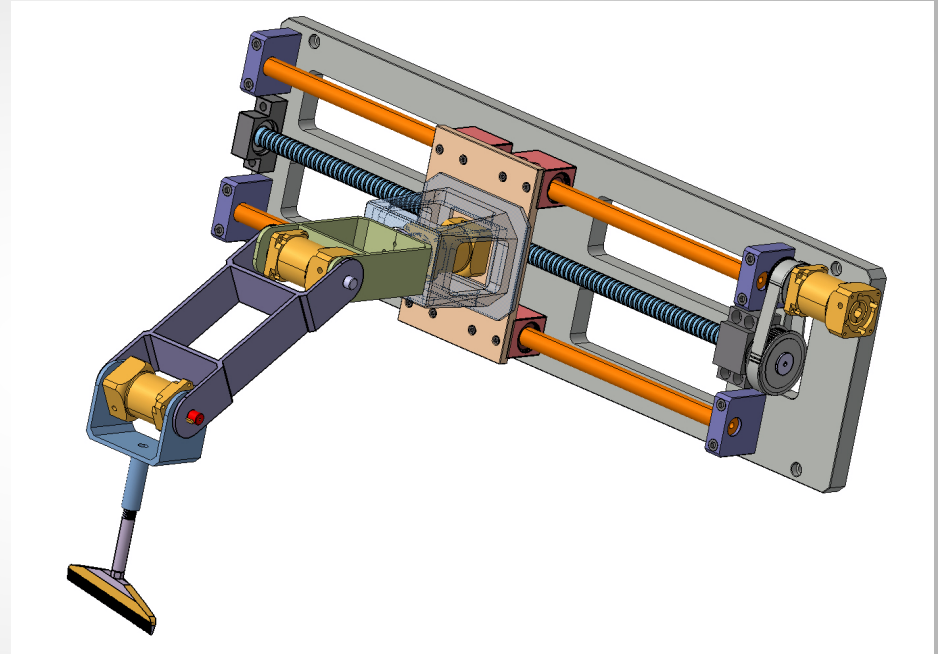


Intro



The DRUNK Robot

Dusting Robot Using Nice
Kinematics



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Tom Wang

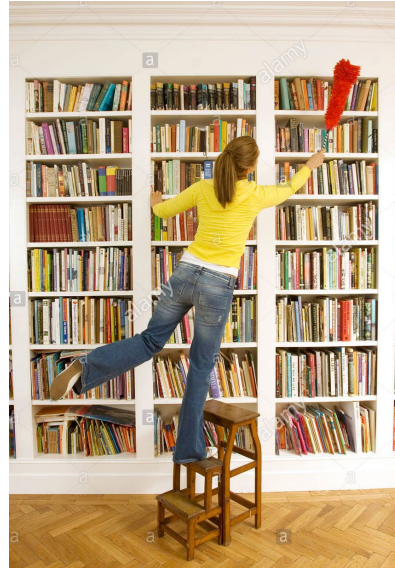
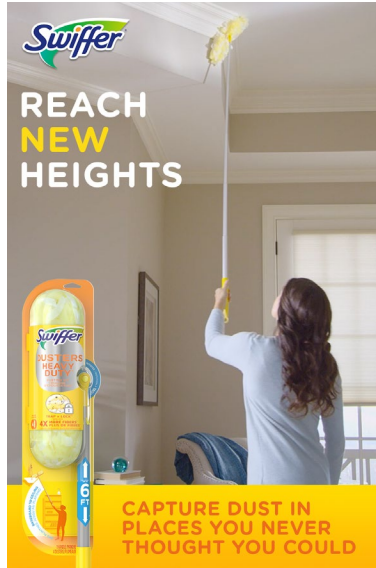
Motivation

- Wiping down surfaces is annoying
- Wiping hard -to-reach surfaces is super annoying
 - Ceiling, high shelves, etc.



Motivation

Current solutions are...

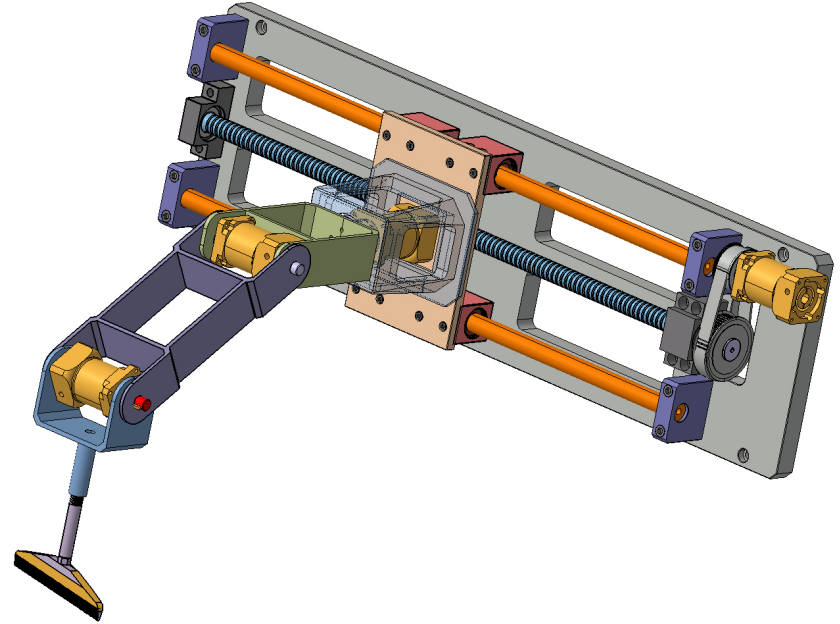


...pretty lame

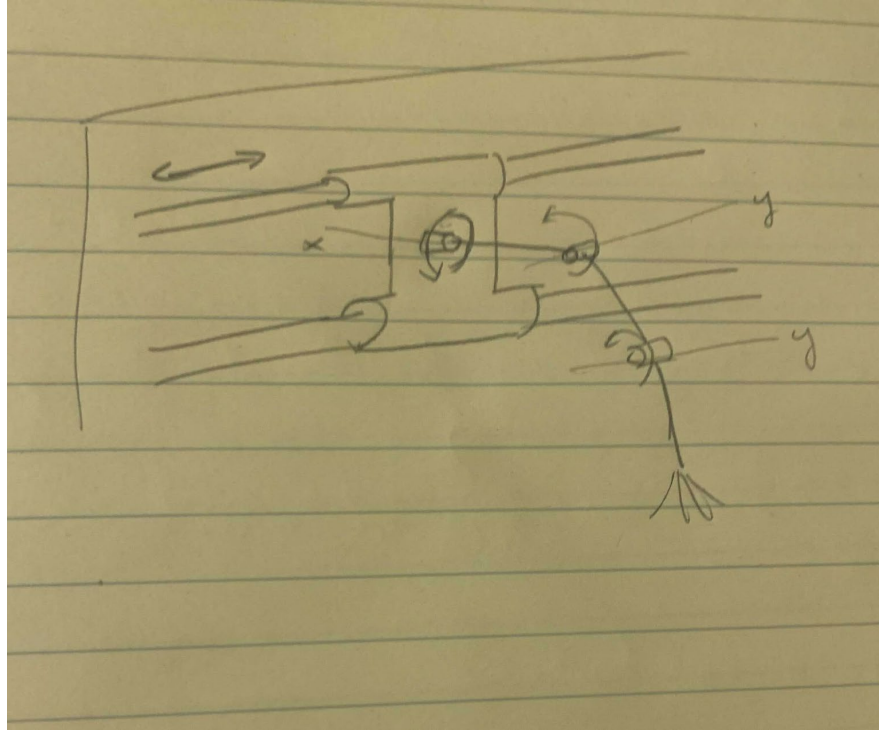
Our Solution

DRUNK

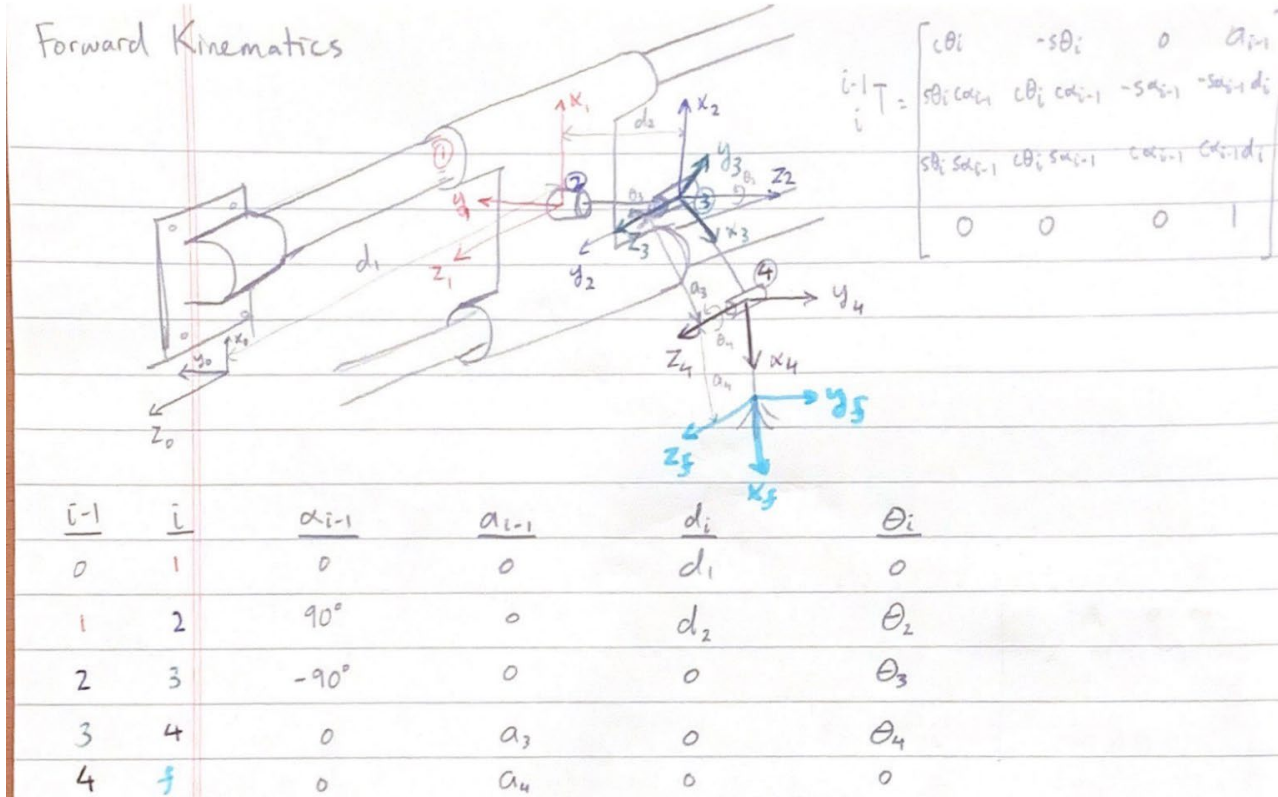
- P-R-R-R
- Mounted on a wall near ceiling
- Interchangeable end effectors
- Cleans high shelves, ceiling, walls



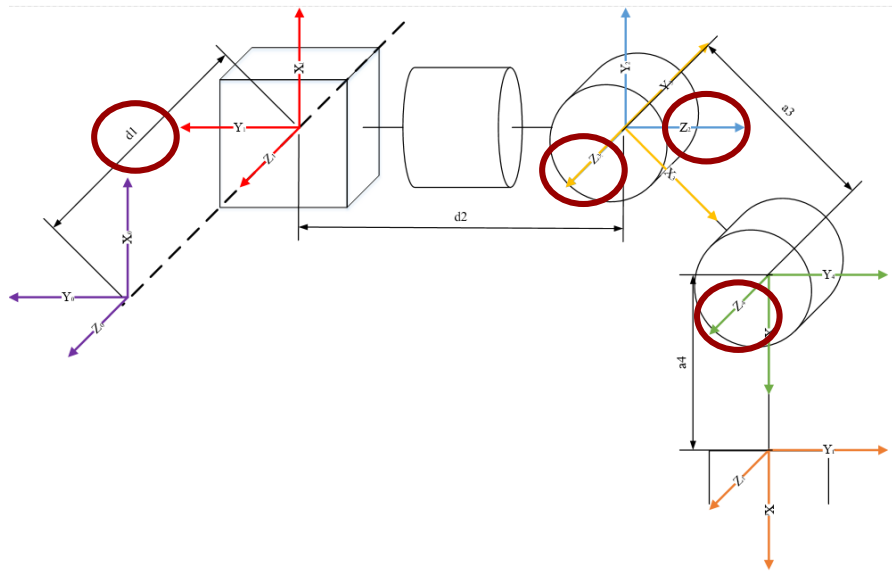
Preliminary Sketch



Forward Kinematics



Forward Kinematics

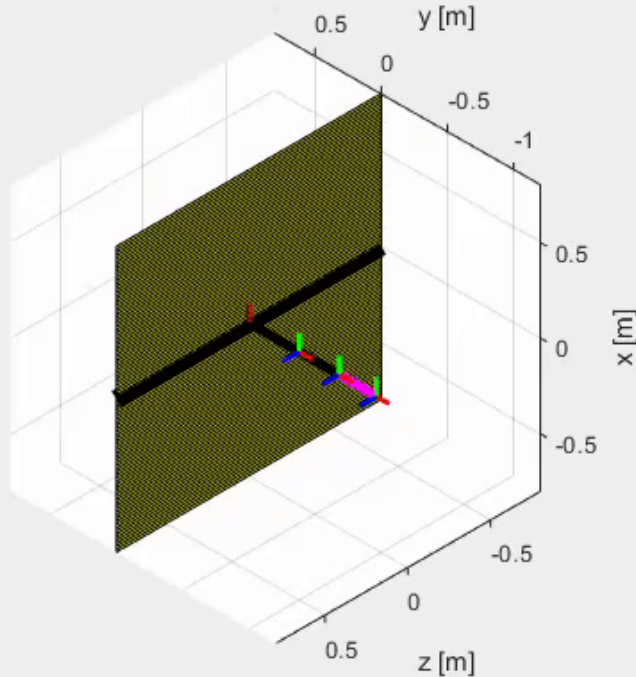


$i-1$	i	α_{i-1}	a_{i-1}	d_i	θ_i
0	1	0	0	d_1	0
1	2	90°	0	d_2	θ_2
2	3	-90°	0	0	θ_3
3	4	0	a_3	0	θ_4
4	f	0	a_4	0	0

$${}^0_fT = {}^0_1T {}^1_2T {}^2_3T {}^3_4T {}^4_fT = \begin{bmatrix} c_2c_{34} & -c_2s_{34} & -s_2 & a_4c_2c_{34} + a_3c_2c_3 \\ s_{34} & c_{34} & 0 & a_4s_{34} + a_3s_3 - d_2 \\ s_2c_{34} & -s_2s_{34} & s_2 & a_4s_2c_{34} + d_1 + a_3s_2c_3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Forward Kinematics

A Little Demo of our Forward Kinematics by changing each joint variables



Joint Variables: $[d1, \theta2, \theta3, \theta4]$

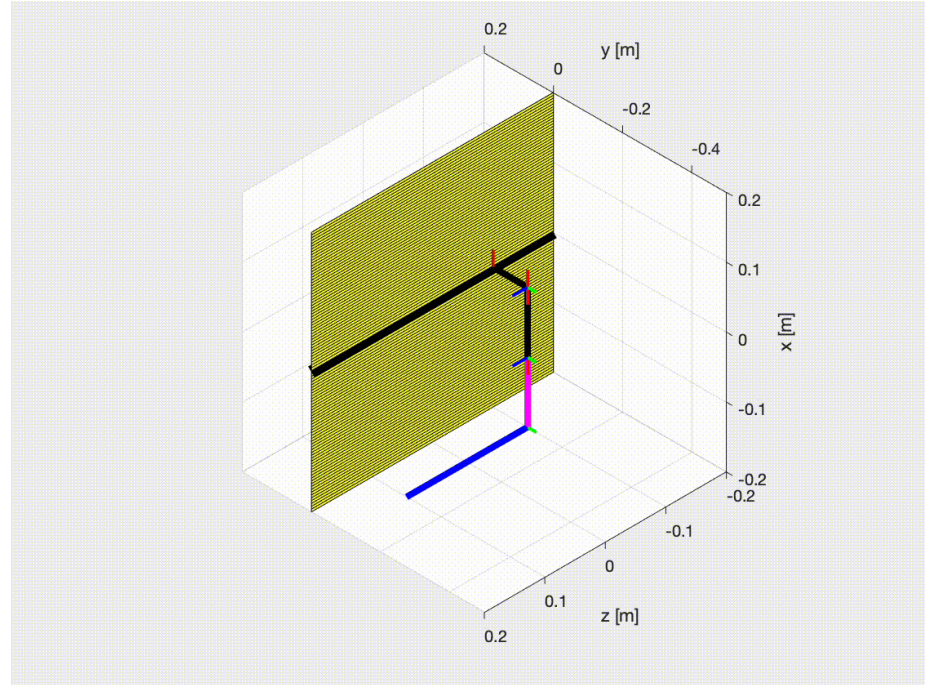
Inverse Kinematics

$$\text{Given } {}^0_fT = \begin{bmatrix} r_{11} & r_{12} & r_{13} & p_x \\ r_{21} & r_{22} & r_{23} & p_y \\ r_{31} & r_{32} & r_{33} & p_z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

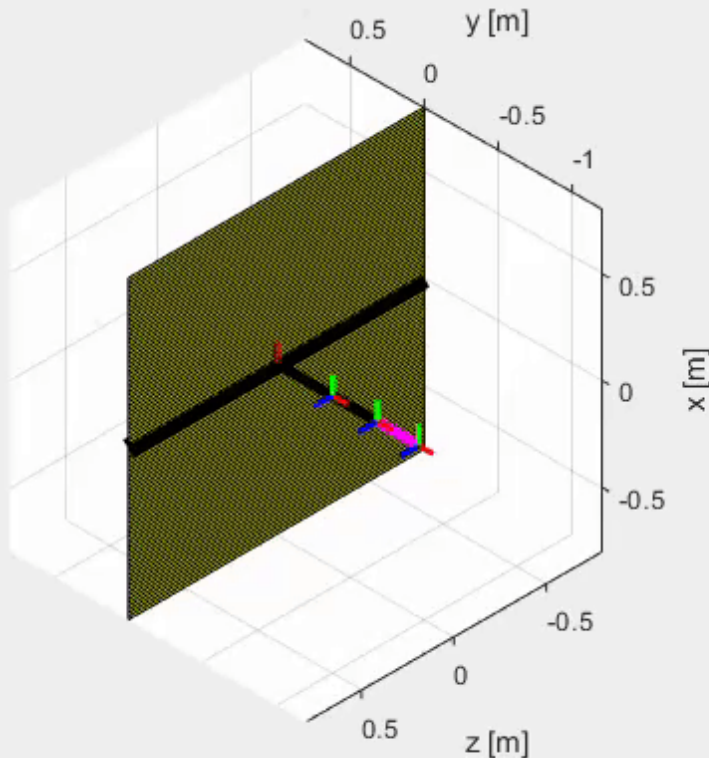
$$\begin{cases} d_1 = p_z + \frac{p_z r_{13}}{r_{33}} \\ \theta_2 = A \tan 2(-r_{13}, r_{33}) \\ \theta_3 = A \tan 2\left[(p_y - a_4 r_{21} + d_2) r_{33}, p_x - a_4 r_{33} r_{22}\right] \\ \theta_4 = A \tan 2(r_{21}, r_{22}) - A \tan 2\left[(p_y - a_4 r_{21} + d_2) r_{33}, p_x - a_4 r_{33} r_{22}\right] \end{cases}$$

Inverse Kinematics

- First, we tested inverse kinematics with a straight line trajectory and constant orientation
- However, we wanted to create a more complicated trajectory using our inverse kinematics that shows the use of all of the joints...

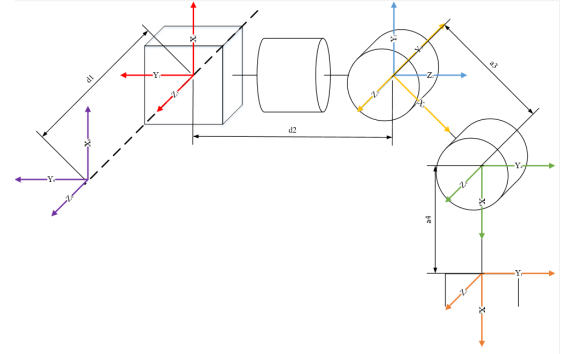


Inverse Kinematics

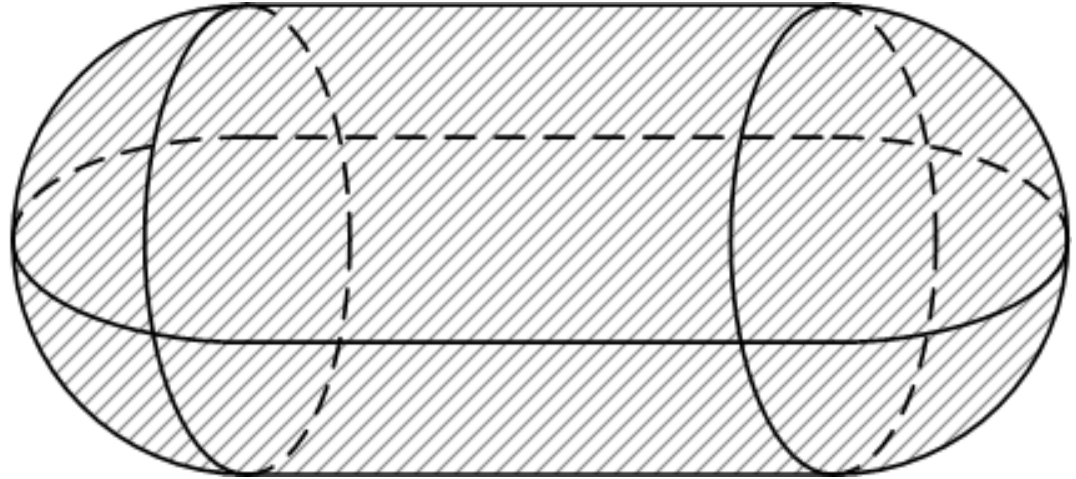
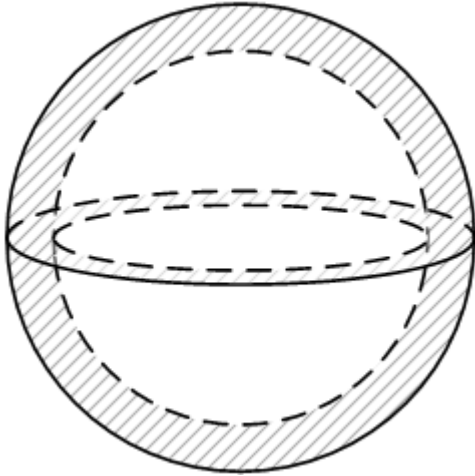


- Remember the more complicated trajectory from 2 slides ago using only the forward kinematics? We were able to reproduce the same animation using the inverse kinematics this time to prove that our inverse kinematics works!
- Now, the challenge is finding more trajectories that may be more suitable to the dusting task that are within our workspace...

Workspace without limitation

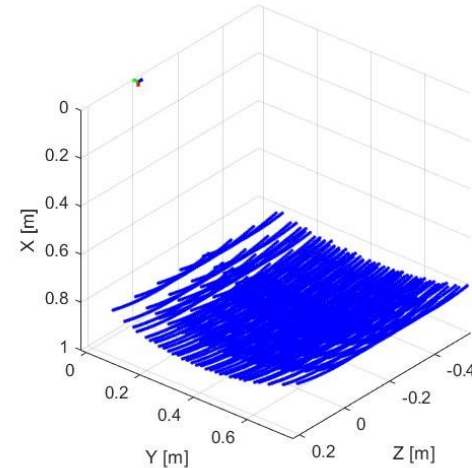
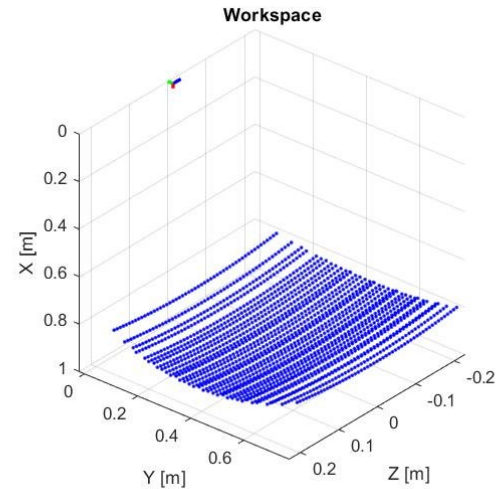
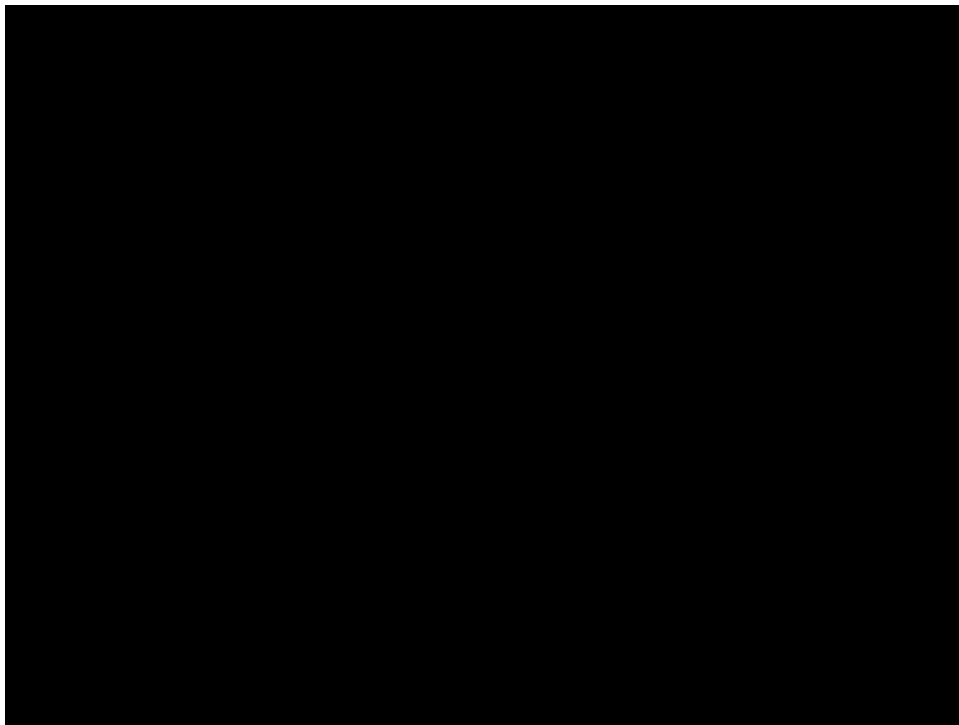


Reachable Workspace:



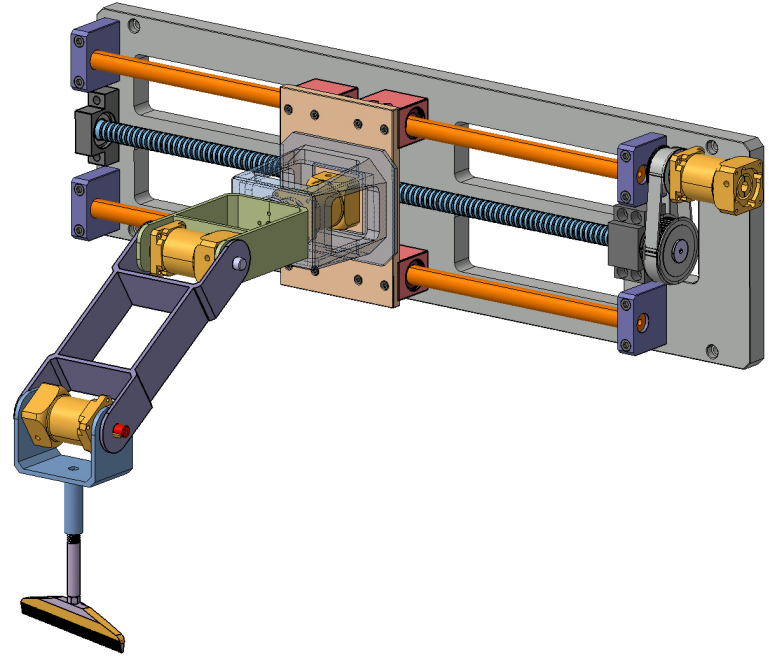
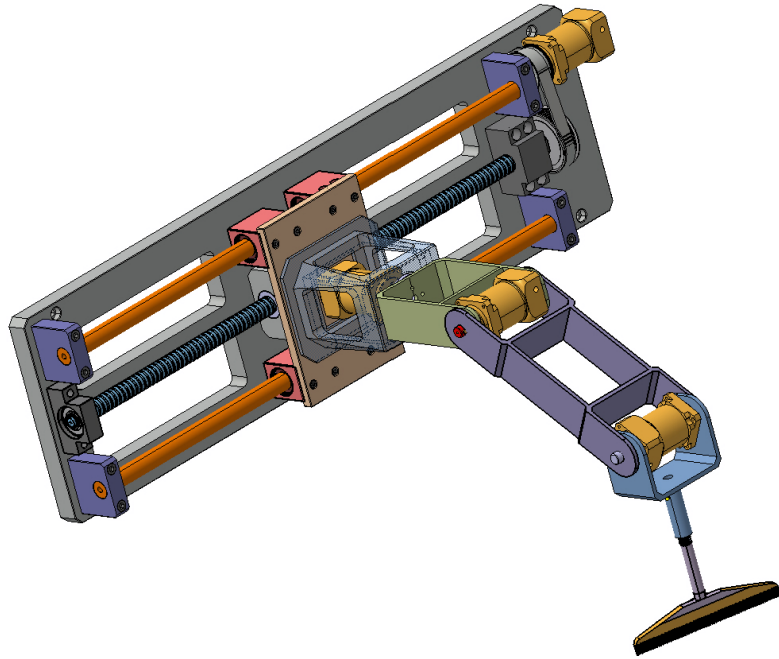
Dexterous Workspace: No.

Workspace with limitation

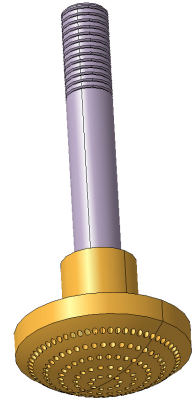
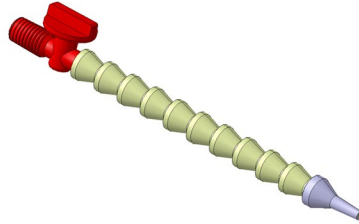
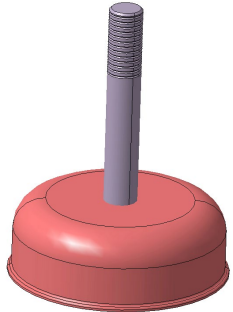
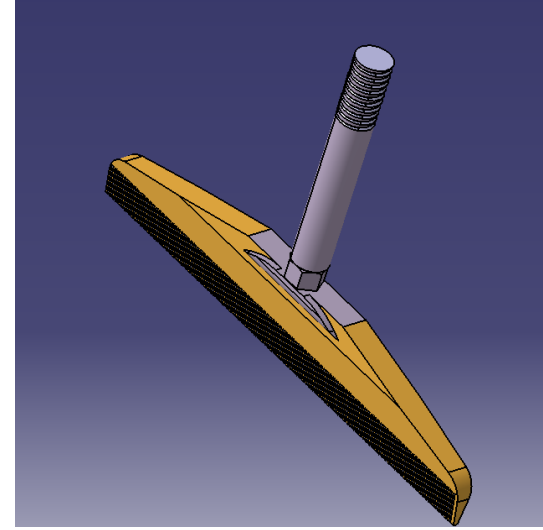
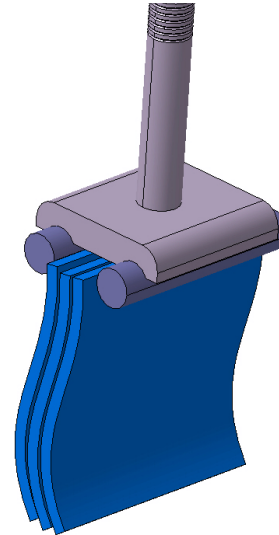
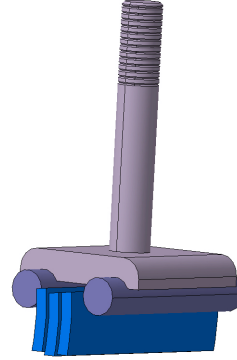
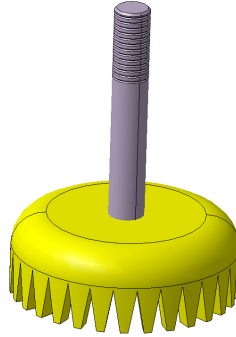
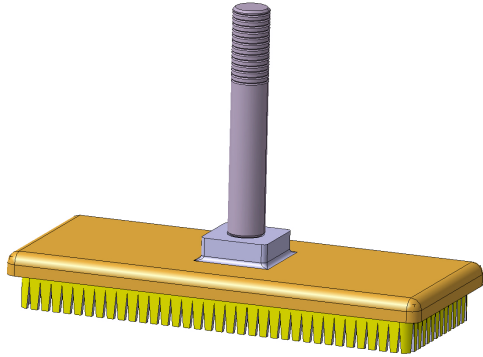


CAD Design

 CATIA

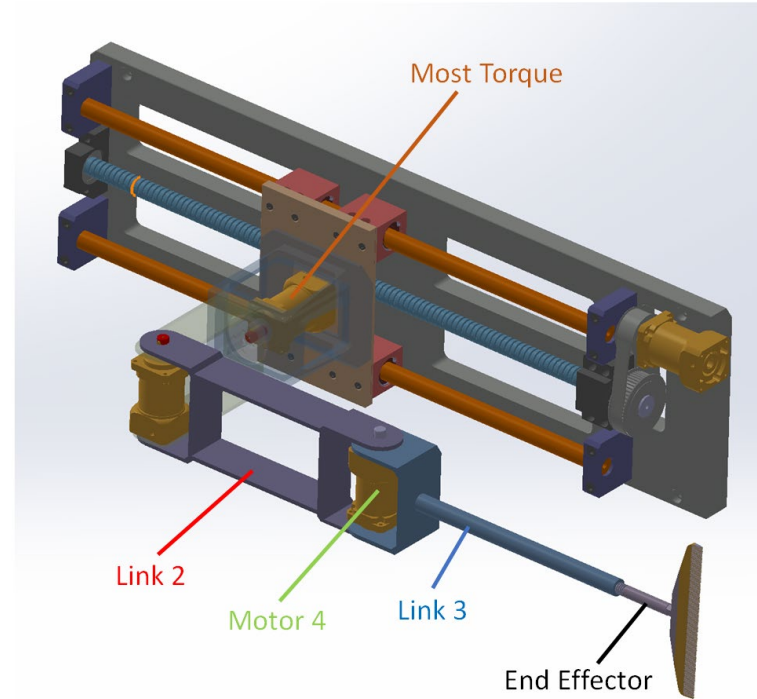


Replaceable End Effector

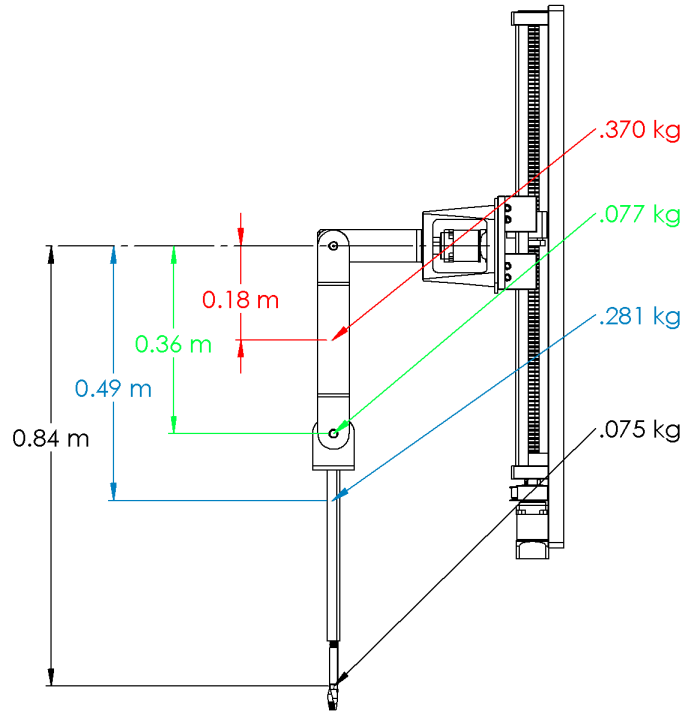


Static Force Analysis

- Put arm in its most “mechanically - disadvantaged” position
- Calculate torque on motor experiencing the greatest torque
- Compare to stall torque of motor



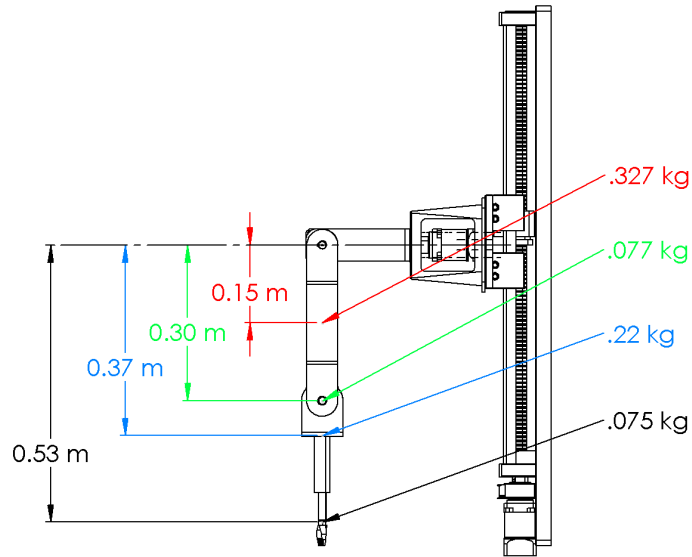
Force Analysis Original



Component	M (N-m)
Link 2	0.653
Motor 4	0.272
Link 3	1.345
End Effector	0.621

Total M = 2.891 N -m > 2.5 N-m stall torque

Force Analysis Redesign



Component	M (N-m)
Link 2	0.481
Motor 4	0.227
Link 3	0.792
End Effector	0.393

Total M = 1.893 N -m < 2.5 N-m stall torque

What's Left?

- Create simulation for desired trajectory
- Secure funding

Thank You

Questions?